GENERAL TECHNICAL SPECIFICATIONS

Biogas Purification & Compressed Biogas (CBG) Production Plants

Bangalore Water Supply and Sewerage Board (BWSSB), Bengaluru

TABLE OF CONTENTS

1. INTRODUCTION AND SCOPE....5
2. GENERAL SITE AND ACCESS ARRANGEMENTS....5
2.1 Access to Site....5
2.2 Access for Other Contractors....5
2.3 Survey and Geotechnical Data....6
2.4 Concessionaire's Bengaluru Satellite Office....6
2.5 Interface with Other Contracts....6
2.6 Maintenance of the Site....6
2.7 Site Working Hours....6
2.8 Water, Utilities and Camp Facilities....6
2.9 Safety and Security on Site....6
2.10 Delivery, Storage and Protection....7
3. GENERAL CONTRACT AND MANAGEMENT REQUIREMENTS....7
3.1 Programme....7
3.2 Contract Management....7
3.3 Meetings and Reporting....7
3.4 Site Photographs and Drone Surveys....7
3.5 Procurement and Balanced Project Progress....7
3.6 Mandatory Reports....8
4. TECHNICAL STANDARDS AND APPLICABLE CODES....8
4.1 General Requirement....8
4.2 Applicable Statutory Regulations and Standards....9
4.3 Key Civil and Structural Codes....9
4.4 Applicable Codes for Painting....9
5. QUALITY ASSURANCE AND ENVIRONMENTAL PROTECTION....11
5.1 Quality Assurance Policy....11
5.2 Quality Plan....11
5.3 Drawing Approval Status Codes....11
5.4 Environmental Protection....11
6. GENERAL WORKMANSHIP, MATERIALS AND DESIGN REQUIREMENTS....12
6.1 Materials – General....12
6.2 Workmanship – General....12
6.3 Design Life....12
6.4 Welding....12
6.5 Castings....12
6.6 Lubrication....12
6.7 Safeguarding of Machinery....13
6.8 Rating Plates, Nameplates and Labels....13
6.9 Spare Parts....13
6.10 Tools and Test Equipment....13
6.11 Instruments – General....13
7. PLANNING, DESIGN AND LAYOUT REQUIREMENTS....14

7.1 Design General....14
7.2 Modular Design for Reliability and Expandability....14
7.3 Plant Layout Requirements....14
7.4 Common Facilities....14
7.4.1 Plant Water System....14
7.4.2 Potable Water System....15
7.5 Design Requirements – General....15
8. CIVIL AND STRUCTURAL WORKS – GENERAL SPECIFICATIONS....15
8.1 General Building Requirements....15
8.2 Cement, Aggregates and Concrete....15
8.3 Reinforcement, Steel and Hardware....16
8.4 Design Loads....16
8.5 RCC and Structural Steel Design....16
8.6 Pre-Engineered Buildings (PEB)....16
8.7 Biogas Process Integration and Layout....17
8.8 Access, Maintenance, Ventilation and Lighting....17
9. MECHANICAL WORKS – GENERAL SPECIFICATIONS....18
9.1 General Mechanical Design Requirements....18
9.2 Piping and Valves....18
9.3 Pressure Vessels....18
9.4 Gaskets and Joints....19
9.5 Environmental Design Criteria....19
9.6 Painting and Surface Protection....19
9.7 Skid-Mounted Equipment....19
10. ELECTRICAL WORKS – GENERAL SPECIFICATIONS....19
10.1 Service Conditions....19
10.2 Equipment Rating and Power Sizing....19
10.3 Voltage Drop....20
10.4 Power Supply Distribution System....20
10.5 Hazardous Area Electrical Requirements....20
10.6 Earthing and Lightning Protection....20
10.7 Cables....20
10.8 Lighting System....21
10.9 Major Electrical Equipment – Summary....21
11. INSTRUMENTATION, CONTROL AND AUTOMATION – GENERAL SPECIFICATIONS....21
11.1 General Requirements....21
11.2 Flow Measurement....22
11.3 Pressure and Temperature Measurement....22
11.4 PLC-Based Control System....22
11.5 Gas Detection and Fire Alarm....22
11.6 SCADA Architecture and Control Philosophy....22
12. SAFETY AND HEALTH REQUIREMENTS....23
12.1 Safety Plan....23

12.2 Health and Safety Staff....23
12.3 Gas Safety – Specific Requirements....23
12.4 NHRC Guidelines – Sewer Workers....23
12.5 Warning Signs and Communication....23
13. DRAWINGS, DOCUMENTS AND SUBMISSIONS....24
13.1 Units of Measurement and Drawing Format....24
13.2 Submission Schedule....24
13.3 Key Documents to be Submitted....24
13.4 As-Built Documents....25
13.5 Operation and Maintenance Manuals....25
14. COMMISSIONING, SPARE PARTS AND TRAINING....25
14.1 Pre-Commissioning and Commissioning....25
14.2 Performance Guarantee Test Run (PGTR) Objectives....25
14.3 Spare Parts....26
14.4 Special Tools and Lubricants....26
14.5 Authority Staff Training....26
15. OPERATION AND MAINTENANCE – GENERAL REQUIREMENTS....26
15.1 General O&M Obligations....26
15.2 Civil O&M Requirements....26
15.3 Mechanical O&M Requirements....26
15.4 Electrical O&M Requirements....27
15.5 Instrumentation O&M Requirements....27
15.6 O&M Reporting....27
15.7 Security and Staffing....27
15.8 Handover on Completion of O&M Period....27
16. APPROVED VENDORS LIST....28
16.1 Gas Analysis and Flow Measurement....28
16.2 Gas Compressors and Blowers....28
16.3 Biogas Process and Safety Infrastructure....28
16.4 Automation and Electrical Systems....28
16.5 Criteria for Alternate Vendors....29

1. INTRODUCTION AND SCOPE

This Schedule sets out the General Technical Specifications applicable to the Design, Engineering, Procurement, Supply, Installation, Testing, Commissioning, and Operation & Maintenance (DEPSITCOM) of Biogas Purification and Compressed Biogas (CBG) Production Plants at five (5) Sewage Treatment Plants (STPs) under the Bangalore Water Supply and Sewerage Board (BWSSB), Bengaluru.

These General Technical Specifications cover the following engineering disciplines:

- Section 2 – General Site and Access Arrangements
- Section 3 – General Contract and Management Requirements
- Section 4 – Technical Standards and Applicable Codes
- Section 5 – Quality Assurance and Environmental Protection
- Section 6 – General Workmanship, Materials and Design Requirements
- Section 7 – Planning, Design and Layout Requirements
- Section 8 – Civil and Structural Works – General Specifications
- Section 9 – Mechanical Works – General Specifications
- Section 10 – Electrical Works – General Specifications
- Section 11 – Instrumentation, Control and Automation – General Specifications
- Section 12 – Safety and Health Requirements
- Section 13 – Drawings, Documents and Submissions
- Section 14 – Commissioning, Spare Parts and Training
- Section 15 – Operation and Maintenance – General Requirements
- Section 16 – Approved Vendors List

These specifications are general in nature and applicable uniformly across all five sites. Site-specific parameters, process design capacities, and particular specifications for individual equipment are covered separately in the Particular Technical Specifications (Schedule D – Part A). In the event of any conflict between the General and Particular Specifications, the requirements of the Particular Specifications shall take precedence.

2. GENERAL SITE AND ACCESS ARRANGEMENTS

2.1 Access to Site

The Authority will provide access to the Concessionaire and possession of the Sites for carrying out the Works. The Concessionaire shall be deemed to have inspected the sites, including all access routes, before submitting its Tender. The Concessionaire shall ensure that the biogas purification plant and its components are of a size and weight suitable for access to the place of installation or can be divided into sections of suitable size and weight.

2.2 Access for Other Contractors

The Concessionaire shall allow reasonable access to other Contractors engaged on the Site or on areas adjoining the Site.

2.3 Survey and Geotechnical Data

The Concessionaire shall independently carry out fresh survey, geotechnical investigation, and all other investigations necessary for proper planning, detailed design, and execution of all works under this Contract. Full details of such investigations shall be provided to the Authority for approval.

2.4 Concessionaire's Bengaluru Satellite Office

The Concessionaire shall deploy and designate appropriate staff for coordination with the Authority, responsible for planning, design, construction, installation, and commissioning of the Biogas Purification Plants. The Satellite Office shall be staffed to facilitate and expedite submittals of Detailed Designs, with dedicated staff for civil, process, structural, mechanical, electrical, instrumentation, and health and safety disciplines.

2.5 Interface with Other Contracts

The Concessionaire shall co-ordinate with the Authority and other Contractors to ensure all interfaces are designed, constructed, installed, tested, commissioned, operated, and maintained to provide a fully functional system. The Concessionaire shall be fully responsible for independently field-verifying all relevant information.

2.6 Maintenance of the Site

The Concessionaire shall be responsible for maintaining all site structures, buildings, equipment, display boards, and related services until expiration of the contract period. At each proposed CBG purification plant site, access main-gate and access road extension shall be provided by the Concessionaire.

2.7 Site Working Hours

Site working hours shall be decided in coordination with the Authority.

2.8 Water, Utilities and Camp Facilities

- The Concessionaire shall make its own arrangements for water supply at the site. Exploration of groundwater is not permitted. Use of tertiary/secondary treated wastewater for construction activities is encouraged where available within 10 km radius.
- Adequate and clean toilet and washing facilities shall be provided and maintained throughout construction. Wastewater shall be connected to the nearest public sewer or an adequately sized septic tank.
- The Concessionaire shall be responsible for the provision and maintenance of a safe and metered temporary electrical supply to the site, tested every 3 months for compliance.

- Refuse and rubbish of every kind shall be removed from the site at a minimum frequency of once per week.

2.9 Safety and Security on Site

The Concessionaire shall at all times maintain safe work methods and shall comply with all enactments and regulations relating to safety, security, health, and welfare of all persons who may be affected.

2.10 Delivery, Storage and Protection

The Concessionaire shall be responsible for the transportation, handling, and delivery to site of all Plant and equipment during normal working hours. Storage and protection of all Plant items shall be in accordance with manufacturer's recommendations, with particular consideration for temperature, rain, sunlight, wind, and ground conditions. No metalwork shall be stored directly on the ground.

3. GENERAL CONTRACT AND MANAGEMENT REQUIREMENTS

3.1 Programme

The Concessionaire shall submit within the stipulated time a detailed contract programme using MS Project software (editable soft copy and paper), including:

- Concessionaire's organisational chart with site supervisors and responsibilities.
- Numbers and categories of supervisory, technical, skilled and unskilled labour.
- List and type details of major constructional plant and proposed delivery dates.
- Detailed method statements for all operations.
- Complete resource allocation showing plant, materials, and labour for each part of the Works.
- Coordination with climatic and groundwater conditions.

3.2 Contract Management

The Concessionaire shall nominate a Concessionaire's Representative as sole point of contact, responsible for administration from contract award through design, manufacture, supply, installation, commissioning, and performance testing to final takeover.

3.3 Meetings and Reporting

The Engineer will call meetings at his office, the Concessionaire's office, or at the Site. The Concessionaire shall prepare and submit a daily activity report. Progress shall be monitored using an S-Curve Chart. CCTV cameras installed at the site shall enable real-time monitoring. The Authority may conduct high-level meetings as needed.

3.4 Site Photographs and Drone Surveys

- Photographs shall be taken at original/before construction, during progress, and for record.

- Real-time CCTV footage shall be maintained throughout the contract period.
- Drone images shall be captured monthly; drone videos every 3 months.
- Soft copies shall be the property of the Authority and delivered to the Engineer.

3.5 Procurement and Balanced Project Progress

Procurement and delivery of electro-mechanical equipment shall be planned in coordination with civil construction progress. The Concessionaire shall ensure civil works reach substantial completion before delivering major equipment to site. A single equipment package shall not be split among multiple vendors. Any procurement-related concerns shall be identified and addressed transparently at an early stage.

3.6 Mandatory Reports

The following reports shall be submitted by the Concessionaire at various project stages:

Design and Construction Period:

a) Site Survey and Geotechnical Investigation Reports
b) Concept Design Reports: Process, Civil, Structural, Mechanical, Electrical, Instrumentation, Control & Automation, Architectural Works
c) Fault Level Calculations and Load Flow Studies
d) Energy Optimization Plan
e) Implementation Report on Cyber Security
f) Monthly Environmental Monitoring Reports
g) Monthly Project Progress Reports
h) Operation & Maintenance Manuals
i) Training Programme and Manuals
j) Other reports if any as required by the Authority

Operations and Maintenance Period:

a) Monthly operational performance report with KPIs
b) Monthly Revenue Report
c) Monthly Incident Report
d) Monthly Environmental Monitoring Reports
e) Annual Maintenance Compliance Report
f) Annual Report on Human Resources Deployed
g) Other reports if any as required by the Authority

4. TECHNICAL STANDARDS AND APPLICABLE CODES

4.1 General Requirement

All plant, materials, and workmanship shall comply with the requirements of the relevant Indian Standards (IS) issued by the Bureau of Indian Standards. Equivalent national or international standards (ISO, IEC, BS EN) may be substituted with the Engineer's approval, provided they are

more stringent than the equivalent IS. All standards used shall be the latest current revision.

In the event of conflict between this Specification and applicable codes, the most stringent provision shall govern unless otherwise approved by the Authority.

Standard abbreviations used in this document:

IS	Indian Standard
ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society of Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
ISO	International Organization for Standardization
JIS	Japanese Industrial Standard
DIN	Deutsches Institut für Normung
BS	British Standard
IEC	International Electro technical Commission
IEE	Institution of Electrical Engineers
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Association
OISD	Oil Industry Safety Directorate
NFPA	National Fire Protection Association

4.2 Applicable Statutory Regulations and Standards

- Indian Electricity Rules (IER) and Central Electricity Authority (CEA) Regulations
- National Electrical Code of India 2023 (SP 30)
- IS 732:2019 – Electrical Wiring Installations
- Bureau of Indian Standards (BIS) Codes and Bureau of Public Enterprise (BPE) Norms
- National Building Code of India and Bye-laws of Town & Country Planning Organisation
- Karnataka State Pollution Control Board (KSPCB) Norms
- Central Pollution Control Board (CPCB) Norms and Environmental Clearance Conditions
- OISD-STD-118: Layout of Oil & Gas Installations
- OISD-STD-163: Process Control Room Safety
- Factory Acts / State Government Factory Acts
- Guidelines of IGBC / GRIHA / LEED for Green Building Concept

- NFPA Standards and Tariff Advisory Committee (TAC) Rules

4.3 Key Civil and Structural Codes

- IS 456: Code of Practice for Plain and Reinforced Concrete
- IS 800: Code of Practice for General Construction in Steel
- IS 875: Code of Practice for Design Loads
- IS 1786: High Strength Deformed Steel Bars and Wires for Concrete Reinforcement
- IS 1905: Code of Practice for Structural Use of Unreinforced Masonry
- IS 3370: Code of Practice for Concrete Structures for Storage of Liquids
- IS 4984: HDPE Pipes; IS 4985: UPVC Pipes
- IS 2720: Methods of Test for Soils
- IRC Standards: Road Design Codes

4.4 Applicable Codes for Painting

- IS 2524; IS 6278; IS 13183; IS 158; IS 2074; IS 104; IS 2932; IS 2629
- BS EN ISO 14713: Protection of Iron & Steel Structures Against Corrosion
- ISO 8501; ISO 8502; ISO 12944: Paint and Coating Standards

5. QUALITY ASSURANCE AND ENVIRONMENTAL PROTECTION

5.1 Quality Assurance Policy

The Concessionaire shall apply the formal requirements of Quality Assurance to the design, supply, construction, and maintenance of the Works through a Quality System compliant with BS 5750 or equivalent international standard. A formal Quality Policy statement shall be included in the Concessionaire's Quality Manual.

5.2 Quality Plan

A comprehensive Quality Plan shall be established and submitted to the Engineer for approval, covering Management Procedures, Design, Supply/Procurement, Construction, Commissioning, Operator Training, Interface Control, and Quality Performance Monitoring. All Sub-Concessionaires and sub-consultants shall establish equivalent Quality Systems and provide evidence of their implementation.

5.3 Drawing Approval Status Codes

The following drawing and document approval status codes shall be used throughout the project:

Status	Details
A	Approved – Manufacture / construction may commence.
B	Acceptable subject to changes indicated – resubmit for approval but manufacture / construction may commence.
C	Amend as comments indicated and resubmit for approval.
D	Comments noted in memo attached to forwarding transmittal – amend and resubmit for approval.
E	Amend as comments indicated and resubmit for record.
F	For information only – not required to be approved.
G	Comments noted – amend as indicated and resubmit for record.
H	Returned without review.

5.4 Environmental Protection

The Concessionaire shall minimise, as far as practically possible, the effects of all activities upon the environment, and shall implement and monitor measures to prevent:

- Contamination of surfaces, ground, groundwater, surface water, and rivers.
- Emissions to air including smells, gases, smoke, and dust.
- Unsanitary or unsafe storage or discharge to drain, sewer, or surface waters.
- Unsanitary or unsafe storage or disposal of solid waste.

- Noise, visual intrusion, and excessive energy and water consumption.

Monthly monitoring reports shall be submitted as part of the monthly progress report.

6. GENERAL WORKMANSHIP, MATERIALS AND DESIGN REQUIREMENTS

6.1 Materials – General

All materials incorporated into the Works shall be new, of first-class commercial quality, free from imperfections, and selected for long life and minimal maintenance. All submerged moving parts in contact with water, sludge, or sewage shall be of corrosion-resistant metals. All parts in contact with chemicals shall be completely resistant to corrosion or abrasion.

- Stainless steel shall meet minimum resistance equivalent to ASTM A276 Gr.410 for forgings and BS EN 10293:2015 Gr. 410-C-21 for castings.
- Bronze shall be zinc-free to BS EN 1982:2017. Prevention of bimetallic corrosion shall be addressed in the design.
- All submerged hardware including nuts, bolts, studs, and washers shall be SS 316L material.
- All bolts, nuts, and screws subject to frequent adjustment or removal shall be of nickel-bearing stainless steel.

6.2 Workmanship – General

Workmanship and general finish shall be of first-class commercial quality in accordance with best workshop practice. All similar items of plant and component parts shall be completely interchangeable. All equipment shall operate without excessive vibration, with the minimum of noise. All rotating parts shall be dynamically balanced. All bearings shall have an L-10 rating life of minimum 16,000 hours.

6.3 Design Life

- Minimum plant design life: 20 years.
- Process equipment, mechanical, electrical, and instrumentation items: minimum 20 years.
- Civil structures and structural steel: minimum 50 years.
- No part subject to wear shall have a life from new to replacement of less than 3 years of continuous normal operation.
- Where significant dismantling is required to replace a part, such life shall not be less than 15 years.

6.4 Welding

All welding shall comply with BS EN 1011. Welding procedure approval shall be per BS EN ISO 15614. Welders shall be qualified per BS EN 287-1:2004. Where welds are likely to be highly stressed, the Concessionaire shall supply detailed weld preparation drawings to the Engineer for approval before fabrication commences.

6.5 Castings

All cast iron shall be of standard grey, close-grained quality as per BS EN 1561 / IS 210 Gr 220 or better. Structures shall be homogeneous and free

from non-metallic inclusions. Minor defects not exceeding 12.5% of total metal thickness may be repaired by approved welding techniques with Engineer notification. Castings with repairs shall be stress relieved after such welding.

6.6 Lubrication

The Concessionaire shall furnish a complete schedule of recommended oils and lubricants with a minimum number of different types. Oil-lubricated bearings shall be provided with an oil reservoir capable of automatically maintaining correct oil level. Adequate flushing oil and lubricants for two years' operation after the taking-over certificate shall be supplied.

6.7 Safeguarding of Machinery

All rotating shafts, couplings, gears, flywheels, belt drives, or other moving parts shall be fully guarded. Guards shall provide ready access to bearings, grease points, and other check points for routine observation and servicing without dismantling. Installation layouts shall not allow any plant to be positioned in a manner posing danger to operating personnel.

6.8 Rating Plates, Nameplates and Labels

- Each main and auxiliary item of plant shall have a permanently attached nameplate showing manufacturer's name, type, serial number, loading and duty details.
- Indoor labels: rigid, laminated and engraved plastic, black capitals on white background, secured with non-rusting screws.
- Weatherproof labels: vitreous enamelled or brass secured with brass / non-rusting round-head screws.
- All process units, storage tanks, and buildings shall be labelled with name, sizes, and volume. Letters shall be minimum 100 mm high.
- All plant items shall be fitted with a unique nameplate and asset number with QR code linked to the master asset database.

6.9 Spare Parts

The Concessionaire shall supply details of recommended spare parts required for continuous operation for a minimum period of 10 years. All spare parts shall be new, unused, strictly interchangeable, treated, and packed for long-term storage. Spares shall be delivered to site before the start of commissioning tests. All spare requirements shall be instantaneous throughout the O&M period.

6.10 Tools and Test Equipment

The Concessionaire shall supply details of all recommended special tools and test equipment required for erection, dismantling, or testing of any part of the Plant. Tools shall be supplied in clearly marked boxes with lists affixed to the inside of the lid. Tools shall be handed over to the Authority in a completely new and unused condition.

6.11 Instruments – General

Indicating and recording instruments shall be flush-mounted, dust- and moisture-proof, and approved by the Engineer. Pressure gauges shall be at

least 150 mm diameter with stainless steel, bronze, or other corrosion-resistant internal components. All outdoor instruments shall be provided with locked, galvanised metallic enclosures of 2 mm thickness, suitably painted. All instruments shall be calibrated using standard reference instruments from Government-recognised institutions.

7. PLANNING, DESIGN AND LAYOUT REQUIREMENTS

7.1 Design General

All designs for Civil, Mechanical, Electrical, and ICA (Instrumentation, Control, and Automation) works shall adhere to the latest revisions of relevant BIS specifications, Codes of Practice, or applicable international standards. The Concessionaire shall be solely responsible for all equipment design and performance.

7.2 Modular Design for Reliability and Expandability

The design and construction of the proposed works shall be executed such that future expansion to double the current installed capacity can be accomplished easily and in a modular manner while maintaining the current capacity fully operational at all times. All components shall be designed using multiple, suitably sized unit process modules to ensure reliability, redundancy, and appropriate turndown.

7.3 Plant Layout Requirements

The CBG Purification Plant and all components shall be laid out within the designated site boundaries, limited to 3,000 m^2 per site except K&C Valley where the limit is 4,000 m^2. The following minimum layout requirements apply:

a) A comprehensive 3D model walkthrough video shall be presented to the Engineer before finalising the plant layout.

b) Minimum clear distance between adjacent treatment units or fixed structures: 3 m; between pieces of equipment: 1.2 m.

c) Access and maintenance lay-down area adjacent to all mechanical equipment.

d) All process equipment including mechanical, electrical and instrumentation shall be located above the high flood level elevation at each site.

e) Minimum 1,500 mm wide continuous walkway from inlet to outlet and thereafter to PLC/SCADA room; walkway crossings with internal roads to be painted as 'WALKWAY'.

f) Minimum 1,200 mm clear width of platform to all process units.

g) All plant internal roads and approach roads shall be asphalt macadam with minimum 3.5 m kerb radius, curb stones on both sides, and edge line markings.

h) Minimum 750 mm paved walkway on either side of roads, 300 mm above road surface.

i) Access facilities for People with Disabilities shall be provided at all ground floor locations.

j) Plant speed limit: not more than 15 kmph; displayed at all road intersections.

k) CCTV cameras at sufficient locations for round-the-clock monitoring;

l) All buildings/structures to have wall-mounted 15-inch digital touch screens showing real-time temperature and noise levels.

7.4 Common Facilities

7.4.1 Plant Water System

All plant water requirements shall be taken from the treated water storage tank. A pressurised plant water booster system shall maintain a minimum pressure of 4.0 bar at the furthest point on the ring main under conditions of maximum plant water use. A separate overhead tank shall be provided. All hydrants shall be labelled as 'Non-Drinking Water'.

7.4.2 Potable Water System

An underground break tank of minimum capacity 7,000 litres shall be provided. A skid-mounted 500 LPH RO purifier shall be installed near the Admin Building. A potable water booster system shall maintain a minimum pressure of 1.5 bar at the furthest point on the ring main.

7.5 Design Requirements – General

- A complete Hazardous Area Classification analysis as per BIS standards shall be performed; all electrical equipment shall comply with IS 5571.
- All components shall have appropriate isolation devices (valves, gates) for isolation, drainage, cleaning, calibration, servicing, and maintenance. Bypass arrangements with isolation valves upstream, downstream, and on bypass (total 3 nos.) shall be provided for all process units.
- All equipment, particularly compressors and blowers, shall be provided with acoustic enclosures to limit ambient noise.
- Fixed runways, lifting eyes, cranes, hoists, or other devices shall be provided for safe removal of all equipment; minimum 1.5 safety factor over maximum lifting weight.
- All structures shall be designed so they can be fully drained and will not float when empty.
- All concrete structures in contact with biogas or sludge shall have full interior corrosion protection linings or coatings.
- All pipelines shall be colour-banded and labelled with stream designation and direction of flow.
- Energy metering shall be provided for all process-specific energy consumption; displayed locally and connected to plant SCADA for remote monitoring.
- Equipment efficiency shall be not less than 80% throughout service life. Priority shall be given to higher-efficiency, lower power-consuming equipment.
- Mature trees shall be provided around the full boundary of all sites, except at accesses, to minimise odour and visual impact.

8. CIVIL AND STRUCTURAL WORKS – GENERAL SPECIFICATIONS

8.1 General Building Requirements

The Control Building / PLC-SCADA Room shall be a minimum of 3 m × 5 m, constructed as RCC or insulated pre-engineered structure with anti-static vitrified flooring, fire-rated steel doors, and split air-conditioning. All process and administrative buildings shall incorporate adequate ventilation, adequate illumination (minimum 300 Lux in process areas using LED fixtures), and HVAC as appropriate.

- Buildings shall have plumbing and drainage, fire detection and suppression (smoke detectors and portable extinguishers), CCTV provision with minimum 60-day recording, and dedicated instrument and power earthing systems.
- All non-skid floor tiles of industrial grade shall be provided on all walkways and staircases.
- RCC staircases shall be provided to all treatment plant units and elevated platforms where floor height exceeds ground level.

8.2 Cement, Aggregates and Concrete

- Cement: Ordinary Portland Cement or Pozzolanic Portland Cement conforming to IS:455 / IS:8112 / IS:12269 as applicable.
- Fine aggregate: clean, well-graded river sand or crushed stone sand; free from organic matter.
- Coarse aggregate: hard, durable, clean crushed stone or gravel; maximum size 20 mm for RCC and 40 mm for PCC.
- Design strength of concrete: M25 minimum for all structural RCC; M30 minimum for foundations subject to dynamic loading or heavy vibration; M15 for PCC blinding layers.

8.3 Reinforcement, Steel and Hardware

- Reinforcement: High Strength Deformed (HSD) bars Fe 500 as per IS:1786.
- Binding wire: 18-gauge annealed mild steel wire as per IS:280.
- Structural steel: as per IS:2062 Grade E250 or higher; all exposed structural steel to be hot-dip galvanised per IS 2629.
- Anchor bolts: Grade 8.8 metric hex bolts per ISO 888:2018 / IS:1367.
- All submerged hardware: SS 316L. All gratings: 6 mm minimum thick Durbar / non-slip pattern aluminium.

8.4 Design Loads

- Dead loads: self-weight of all structural elements, equipment, piping, and finishes.
- Live loads: as per IS:875 Part 2, including maintenance loads and equipment removal provisions.
- Wind loads: as per IS:875 Part 3; basic wind speed as applicable for Bengaluru.
- Seismic loads: as per IS:1893 (Part 1); Bengaluru falls in Seismic Zone II.
- Hydrotest loads: full liquid head including 25% additional for dynamic effects.

- Foundation design: as per IS:1904; all foundations shall be below zone of seasonal moisture variation.

8.5 RCC and Structural Steel Design

- All RCC design shall comply with IS:456 – 2000. Minimum cover to reinforcement: 40 mm for foundations, 30 mm for beams/columns, 25 mm for slabs.
- Structural steel design shall comply with IS:800 – 2007 using Limit State Method.
- All welded connections shall comply with IS:816.
- Structural designs shall be submitted with STAAD files (input and output).

8.6Pre-Engineered Buildings (PEB)

a) The intent of this specification is to establish the minimum requirement of design, design certification, engineering, selection, manufacture, assembly, inspection, shop testing, shop painting, delivery FOR site properly packed for transportation suitably protected from weather including transit insurance of all materials, unloading at site, transportation to stores, safe storage at site, insurance against pilferage, transportation from stores to site, final painting, erection, testing, final handling over as mentioned hereinafter for the Pre-Engineered Building (PEB), for housing the Biogas purification plant.

b) The Bidder shall be fully responsible for the completeness and soundness of the PEB as a whole. The PEB shall be designed and executed in accordance with proven, certified design principles and the latest state of the art to ensure that the plant fully meets its intended purpose. Standardized equipment and materials shall be used wherever practicable, and due care shall be taken to ensure safety.

c) The PEB shall be made of structural steel construction with double skinned metal roofing and wall cladding of approved profile. It shall be designed, manufactured, supplied and erected by the bidder. PEB shall be complete with painting, metal facia, metal gutter, rain water down comers, sun-shades, openings, etc., along with associated structural steel, cladding and roofing work insulation, Trims & Flashings. Each structural item like columns, rafters, beams, purlins, steel sheets, insulation etc and also each architectural item like doors, windows, rolling shutters etc of PEB shall be suitable for complete life of biogas purification plant for at least 25 years. The construction methodology for PEB shall also be submitted to Authority approval before start of works.

d) Major supply and services included in Concessionaire’s scope are as follows:

   i. Architectural and structural design of the PEB for locating the Biogas Purification Plant with minimum area of 50sqm with sufficient working space for ease of installation, operation and

maintenance of the plant units, including separate enclosures for electrical panel, security room, and toilet facilities

ii. Supply and erection of PEB structural materials such as columns, rafters, beams, purlins, steel sheets, insulation etc complete

iii. Supply and erection of PEB architectural items such as doors, windows, rolling shutters, etc complete.

iv. Painting works as per prudent industry standard and practice.

v. All plumbing works for providing process water, drinking water, and toilets

vi. Complete civil foundation works and plinth protection

vii. RCC cable trenches within the PEB

viii. Flooring works as per industry standard

ix. Steps/ ramps on front/back sides of the room as applicable

x. Ventilation arrangements in accordance to industry standard and applicable laws for handling Biogas

xi. Complete electrical works including supply, erection and commissioning of wiring, room appliances (lights, ceiling fans, exhaust fans, ventilators, etc), switch boards, MCB boxes etc complete

xii. Cut out/ provision of supports & fixtures for the PEB appliances

8.7 Biogas Process Integration and Layout

- All civil structures within the biogas plant boundary shall be designed to accommodate equipment loads, pipe trench loads, access platform loads, and maintenance vehicle loads.
- Adequate drainage shall be provided around all structures; interception and containment bunds for all chemicals and fuel.
- All piping routed under any structure or equipment shall be fully encased in RCC with minimum 200 mm on all sides, extending at least 1,500 mm horizontally beyond the footprint.

8.8 Access, Maintenance, Ventilation and Lighting

- Ventilation systems shall conform to IS:3646 for natural ventilation and relevant codes for forced ventilation.
- Minimum 300 Lux at working plane for all process areas; emergency lighting shall be provided using a secure power supply.
- Safe means of access including platforms, handrails with toe guards (minimum 100 mm), guardrails (minimum 900 mm), ladders, stairs, and safety chains shall be provided to all equipment and instruments.

9. MECHANICAL WORKS – GENERAL SPECIFICATIONS

9.1 General Mechanical Design Requirements

- Design ambient temperature range: +10°C to +45°C; site conditions: tropical.
- Minimum design life for process equipment: 20 years
- All equipment shall be designed, manufactured, and tested per ASME, API, IS, and other applicable codes.
- Equipment efficiency: minimum 80% throughout service life; preference to be given to lower energy consumption.
- Noise: maximum 85 dB(A) at 1 m from any equipment during normal operation; acoustic enclosures to be provided where required.
- All equipment shall be modular and, wherever feasible, skid-mounted to facilitate future expansion.

9.2 Piping and Valves

- All process gas piping shall comply with ASME B31.3; all piping materials shall be compatible with biogas service (H_2S, moisture, and CO_2 at operating pressures and temperatures).
- All piping shall be fully supported and braced per applicable codes; pipe supports shall account for static, dynamic, seismic, and thermal expansion loads.
- Flexible joints shall be provided at all connections between pipes and equipment to allow for differential movement.
- Pipe lengths and joints shall be assembled for ease of removal by providing dismantling joints at regular intervals.
- All pipelines shall be colour-banded and labelled with stream designation and direction of flow per IS:2379.
- All chemical piping shall be clearly identified, easily accessible, and where installed in ducts, supported at minimum 300 mm from the floor.

9.3 Pressure Vessels

- Design and fabrication shall be per ASME Section VIII Division 1 or IS 2825 as applicable.
- Minimum shell/head thickness: as per design calculations but not less than 6 mm for carbon steel vessels in biogas service.
- Design pressure: not less than 1.1 times the maximum operating pressure (minimum 2.5 bar g for vessels in the biogas purification train).
- Test pressure: 1.3 times design pressure for hydraulic test per ASME / IS requirements.
- Design temperature: 0°C to 55°C; corrosion allowance: minimum 3 mm for carbon steel in biogas or caustic service.
- All vessels in H_2S / caustic service: SS 316L wetted surfaces or CS with Novolac epoxy lining (minimum 300 µm DFT).

9.4 Gaskets and Joints

Joint rings shall conform to BS 7874, BS EN 681-1, BS EN 681-2, and BS EN 682, manufactured from chloroprene rubber or equivalent synthetic material suitable for up to 80°C. Graphite grease shall be applied to bolt

threads before joints are made. Flanges shall be cleaned and gaskets fitted smoothly before tightening alternately in diametrically opposite positions.

9.5 Environmental Design Criteria

- Ambient temperature: 27°C nominal; range 15°C to 45°C.
- Relative humidity: maximum 75%.
- Site classification: tropical.
- All outdoor equipment shall be designed and finished for tropical service without deterioration.

9.6 Painting and Surface Protection

- All uncoated carbon steel surfaces shall be shot-blasted to Sa 2.5 (ISO 8501-1) before painting.
- Internal surfaces of vessels in biogas or caustic service: Novolac epoxy lining, minimum 300 µm DFT.
- External surfaces: 2-coat epoxy primer + 2-coat polyurethane topcoat; minimum total DFT 200 µm.
- Structural steelwork in outdoor service: hot-dip galvanised as per IS 2629 / BS EN ISO 1461.
- Painting and surface treatment shall comply with IS 2524, IS 13183, ISO 12944, and relevant painting standards.

9.7 Skid-Mounted Equipment

All skid-mounted packages shall be supplied complete with all instruments, valves, piping, electrical connections, and accessories within the package skid. Skid frames shall be of structural steel, welded construction, painted per specification. Sole plates, mounting feet, and anchor bolt pockets shall be provided. All drains and vents shall be piped to within 150 mm of the skid edge.

10. ELECTRICAL WORKS – GENERAL SPECIFICATIONS

10.1 Service Conditions

The electrical system shall be designed for operation in a tropical climate with ambient temperature range of +10°C to +45°C and relative humidity up to 75%. All outdoor electrical equipment shall be rated IP55 minimum (IP66 for Zone 1 / Zone 2 hazardous area equipment). All electrical installations shall comply with the Indian Electricity Rules, CEA Regulations, IS 732:2019, and the National Electrical Code of India 2023.

10.2 Equipment Rating and Power Sizing

- All motors >55 kW: minimum 10% oversize margin above maximum process duty.
- All motors 22–55 kW: minimum 15% oversize margin.
- All motors <22 kW: minimum 25% oversize margin.
- Motor design life: minimum 25 years; minimum IP54 (IP55 for terminal box).

- All motors and electrical equipment for hazardous areas (Zone IIA / Zone IIB): Flameproof (Ex-d) or increased safety (Ex-e) as per IS 5571 / IEC 60079; ATEX/PESO certified.
- Power factor at full load shall not be less than 0.85 (with capacitor bank correction as required).

10.3 Voltage Drop

- Maximum voltage drop in power circuits: 4% from the supply terminals of the electrical equipment.
- Maximum voltage drop in lighting circuits: 2%.
- Maximum voltage drop from LV switchboard to any motor terminal: 5%.

10.4 Power Supply Distribution System

- Power supply: 3-phase, 415 V (LV), 50 Hz. HT supply: 11 kV or 33 kV as per State Electricity Board (SEB) requirement.
- Step-down transformer: ONAN type, HV:LV ratio as per SEB requirement; CPRI tested.
- LV Distribution: Main MV Switchboard (MCC/PMCC), draw-out type, type-tested per IEC 61439.
- Emergency power: DG Set with AMF Panel, Dual Incomer + Bus Coupler configuration; capacity as per connected emergency load.
- UPS system: dual redundant, online; Ni-Cd batteries; minimum 120 minutes backup for instruments and SCADA; 60 minutes for other critical loads.
- All motor starters: Direct-on-Line (DOL) for <30 kW; VVVF/Soft Starter for ≥30 kW or as required by process.

10.5 Hazardous Area Electrical Requirements

- Hazardous area classification shall be performed per IS 5572 and IEC 60079-10; HAZOP / QRA by a third-party agency is mandatory.
- All electrical equipment in classified areas: Flameproof Ex-d (Zone 1) or Ex-e / Ex-n (Zone 2), ATEX certified and approved by PESO.
- All electrical and instrumentation equipment in hazardous areas: group IIB, temperature class T3 (200°C) minimum.

10.6 Earthing and Lightning Protection

- Earthing system shall be designed and installed per IS 3043; dedicated instrument earth and power earth with resistance <5 ohm each.
- Separate PLC/DCS earth with resistance <1 ohm.
- Lightning protection system per IS 62305 (BS EN 62305); independent earth pits with resistance <5 ohm.
- Surge protection devices (SPDs) shall be provided on both ends of all outdoor signal cables.

10.7 Cables

- PVC insulated power and control cables: IS 1554; FRLS (Fire Retardant Low Smoke) outer sheath.
- XLPE insulated power cables: IS 7098; FRLS outer sheath.
- All outdoor and underground cables: armoured.
- Cable trays, ladders, conduits: hot-dip galvanised steel; sized per cable schedule.

10.8 Lighting System

- All lighting: LED type; minimum 300 Lux in process and maintenance areas; minimum 150 Lux in roads and outdoor areas.
- Emergency lighting: minimum 50 Lux on escape routes; 10% of total fixtures on UPS or battery backup.
- Lighting in hazardous areas: Flameproof LED fittings (Ex-d) per IS 5571.
- PAGA (Public Address and General Alarm) System: provided at all plant areas.

10.9 Major Electrical Equipment – Summary

Equipment	General Specification
HT Switchgear	Vacuum Circuit Breaker type; type-tested per IEC 62271
MV/LV Switchboard	MCC / PMCC draw-out type; IEC 61439; Form 4b compartmentalisation
Transformers	ONAN, CPRI tested; vector group Dyn11; OTI + WTI protection
DG Set	Prime rated, AMF panel, acoustic enclosure, exhaust stack
UPS	Online double-conversion; min. 120 min backup for instruments
VFD / Soft Starter	IP54 minimum; EMC filter; bypass contactor
Capacitor Banks	Automatic power factor correction; target PF ≥ 0.95
MV Motors	IE3 efficiency class minimum; IP55; Class F insulation

11. INSTRUMENTATION, CONTROL AND AUTOMATION – GENERAL SPECIFICATIONS

11.1 General Requirements

The Instrumentation, Control, and Safety System (ICSS) shall provide fully automated, safe, and continuous plant operation. All instruments shall be selected, installed, and maintained in accordance with relevant IS, ISA, IEC, and OISD standards. The system shall provide continuous monitoring,

automatic control, alarm management, historical data logging, and remote monitoring capability.

- All instruments on gas lines: suitable for Zone 2 minimum hazardous area classification; ATEX/PESO certified.
- All smart field instruments: HART-compatible (4–20 mA); Modbus TCP/IP or equivalent for digital instruments.
- All outdoor instruments: IP65 minimum enclosure, galvanised metallic housing 2 mm minimum thickness.
- All instruments shall be calibrated using standards traceable to Government-recognised institutions.

11.2 Flow Measurement

- Biogas flow metering: thermal mass flow meters or equivalent suitable for wet gas with H_2S.
- CBG / product gas flow metering: Coriolis or ultrasonic; accuracy ±0.5% or better.
- All flow meters on custody transfer duty: ISO 17025 accredited laboratory calibration; Calibration and Measurement Capability (CMC) ≤ ±0.5%.

11.3 Pressure and Temperature Measurement

- Pressure transmitters: smart HART; ±0.1% accuracy; SS 316L wetted parts; minimum IP65.
- Pressure gauges: minimum 150 mm diameter; SS 316L or bronze internals; fitted with isolation stop cock and drain valve.
- Temperature sensors: Pt100 RTD with non-corrodible metal sheath; direct- or thermowell-mounted as applicable.

11.4 PLC-Based Control System

- PLC type: Industrial grade, dual redundant hot-standby CPUs for all critical process controls.
- Minimum spare I/O: 15% on all modules at time of commissioning.
- SCADA: dual redundant servers; historian with minimum 7-year data storage; Siemens WinCC / Schneider EcoStruxure / Rockwell FactoryTalk or equivalent.
- HMI: minimum 15-inch colour touch screen; IP65; provided in control room and locally at process areas.
- Communication: Modbus TCP/IP; redundant managed Ethernet switches; fibre optic backbone for inter-building links.
- Fail-safe logic: all outputs shall default to safe / OFF state on power failure or control failure.
- FAT (Factory Acceptance Test) and SAT (Site Acceptance Test) are mandatory; witnessed by the Engineer and Authority.
- Surge Protection Devices (SPDs) on both ends of all outdoor signal cables.

11.5 Gas Detection and Fire Alarm

- Fixed CH_4 gas detectors (flameproof, ATEX/PESO) at all critical locations; alarm at >20% LEL; automatic isolation at >40% LEL.
- Fixed H_2S detectors at scrubber area and enclosed spaces; alarm set points per OSHA / IS requirements.
- Minimum one portable gas detector per site at all times.
- Fire alarm system: addressable microprocessor-based; clean agent suppression for control room; manual call points at all exits.
- Emergency Stop (ESD) push buttons: hardwired; at control room, all process area entries, and adjacent to all compressors.

11.6 SCADA Architecture and Control Philosophy

- The plant shall operate in fully automatic mode under PLC-SCADA control with manual override capability.
- All process alarms, trips, and ESD signals shall be logged and time stamped by the historian.
- Real-time data shall be shared with the CGD / NGPL entity via Modbus communication for metering, gas quality, and flow.
- Cyber security provisions shall be incorporated per relevant guidelines; implementation report to be submitted as part of mandatory documents.
- Remote monitoring by the Authority shall be enabled via secure VPN or equivalent means.

12. SAFETY AND HEALTH REQUIREMENTS

12.1 Safety Plan

The Safety Plan shall target zero fatal accidents and zero hazardous incidents throughout construction and O&M. The plan shall include policies, site organisation, safety audit frequency, record keeping, reporting, safety training, PPE provision, and qualifications of safety officers.

12.2 Health and Safety Staff

The Concessionaire shall appoint appropriate staff for compliance with the Health and Safety compliance considerations. Appropriate patrolling, daily reporting, and daily safety meetings shall be arranged at the site.

12.3 Gas Safety – Specific Requirements

- An inspection register shall be maintained at the entry of the CBG plant; no unauthorised entry shall be allowed.
- Caution boards showing restricted entry areas and names of components shall be displayed.
- No person below 18 years of age shall be allowed in areas with possible emission of toxic gases.
- Authorised visitors shall be provided with appropriate uniform, visitor badges, helmets, and safety gear.
- All workers in biogas and confined spaces shall be trained in confined space entry procedures.

- Self-Contained Breathing Apparatus (SCBA) and first aid shall always be present at site for emergencies.

12.4 NHRC Guidelines – Sewer Workers

All applicable National Human Rights Commission (NHRC) guidelines and Hon'ble Supreme Court directions on safety of sewerage and allied workers shall be strictly followed, including free medical examination, continuity of employment during illness, payment of compensation on death or injury, provision of protective equipment, and compliance with all statutory labour welfare requirements.

12.5 Warning Signs and Communication

All statutory safety signs – mandatory, prohibition, warning, emergency, fire-fighting, and general notices – shall be displayed throughout the Works, both indoors and outdoors. Warning signs shall be in English, Kannada, and Hindi languages. All site sign boards and contract display boards shall similarly be in all three languages.

13. DRAWINGS, DOCUMENTS AND SUBMISSIONS

13.1 Units of Measurement and Drawing Format

All designs, drawings, specifications, and manuals shall use SI units. Drawings shall use AutoCAD version 2024 (editable). Text documents shall use latest Microsoft Word / Excel. All other information shall be in Adobe PDF version 7.x. Construction drawings shall be on standard A1 paper. All submissions shall be in editable electronic soft copy on CD/DVD, plus 3 hard copies for review and 8 copies for approved documents.

13.2 Submission Schedule

Document Type	No. of Copies
Review submissions (R0, R1, R2…)	3 copies (soft + hard)
Approved B-Code and A-Code documents	8 copies (soft + hard)
As-Built Documents and Drawings	8 copies (soft + hard)
Operation & Maintenance Manuals	15 copies (soft + hard)
Structural designs	Submitted with STAAD files (input and output)

The Authority shall send review observations within 28 calendar days of submission. The Concessionaire shall resubmit within 10 days of receiving comments.

13.3 Key Documents to be Submitted

a) General Arrangement (GA) Drawings
   i. General Arrangement Layout
   ii. Equipment list
b) Process Flow Diagrams (PFD) and Piping & Instrumentation Diagrams (P&ID).
   i. Process design basis
   ii. Process Flow Diagram
   iii. Material Selection Diagram (MSD)
   iv. Process guarantees and Test Procedures
   v. Process & Utilities P&IDs & Legends P&IDs
   vi. Process data sheets of all fixed and rotating equipment
   vii. Process specification of all package items
   viii. Process data sheets of all types of instruments
   ix. Operating and control philosophy
   x. Alarm and trip schedule
   xi. Cause and effect diagram
   xii. Isolation philosophy
   xiii. Line schedule
c) Foundation Drawings for all major equipment.
d) Electrical Single Line Diagrams (SLDs), load calculations, and cable schedules.
e) Instrument Index, I/O List, Cause & Effect Matrix, and Functional Description Specification (FDS).
f) Hazardous Area Classification Drawings (as per IS 5572 / IEC 60079-10).
g) Structural design calculations with STAAD files.
h) Quality Assurance Plan (QAP) and Inspection & Test Plan (ITP).
i) Performance Guarantee Test Run Report
j) Pre-commissioning and commissioning manual
k) Operation & Maintenance Manuals (covering process, civil, mechanical, electrical, instrumentation, and control).
l) As-Built Drawings for all civil, mechanical, electrical, and instrumentation works.
m) FAT records and SAT records for all Plants and Works.

13.4 As-Built Documents

As-built drawings shall be submitted 56 calendar days before the commencement of Tests on Completion. A3 and smaller sized drawings shall be provided on durable paper for photocopier reproduction. Larger drawings shall be provided as paper copies and in AutoCAD (latest version) on CD, in two sets. Final as-built drawings shall be submitted prior to issue of any Taking Over Certificate.

13.5 Operation and Maintenance Manuals

O&M Manuals shall be compiled by the Concessionaire and submitted in draft form at least 56 calendar days prior to commencement of Tests on Completion. The manuals shall include general descriptive text, complete

operational instructions, essential mechanical and electrical maintenance schedules, maintenance log sheets, and fault location / overhaul procedures. Each volume shall be enclosed in A4 ring binders with tough covers and comprehensive indexes.

14. COMMISSIONING, SPARE PARTS AND TRAINING

14.1 Pre-Commissioning and Commissioning

The Concessionaire shall develop and submit a commissioning procedure covering pre-commissioning checks, instrument loop checks, interlock testing, and field trial run tests for all systems and sub-systems. Commissioning shall be phased so as not to obstruct other ongoing works.

- All instruments to be calibrated and calibration reports submitted at least 7 days before Performance Guarantee Test Run (PGTR).
- Joint protocol format and sample log sheets shall be submitted to the Engineer at least 7 days before PGTR.
- PGTR shall be considered successfully completed only when total purified CBG is generated for 3 consecutive days at the agreed quality and pressure.

14.2 Performance Guarantee Test Run (PGTR) Objectives

- Verify healthy working of all equipment.
- Log all operating parameters with online instruments at the time of capacity test.
- Measure noise and vibration levels.
- Verify satisfactory operation of all interlock protection devices.
- Verify capacity, purity, and discharge pressure of purified CBG.

14.3 Spare Parts

Start-up and commissioning spares shall be agreed and procured before commissioning commences. A list of recommended two-year operational spares and 10-year operational spares shall be submitted. All spares shall be new, unused, and interchangeable with the original parts. Spares shall be delivered to site before the start of commissioning tests. All spare requirements shall be maintained instantaneously throughout the O&M period.

14.4 Special Tools and Lubricants

- All special tools required for erection, dismantling, or testing of any part of the Plant shall be supplied and clearly identified.
- Adequate flushing oil and lubricants for 2 years of operation after taking-over certificate shall be supplied.
- Temporary facilities required during commissioning, including scaffolding, lifting equipment, testing instruments, and consumables, shall be included in the Contract scope.

14.5 Authority Staff Training

The Concessionaire shall provide comprehensive training for Authority's staff before commencement of plant operation, covering:

- Process description, equipment operation, and control system operation (classroom and hands-on).
- Maintenance procedures for all major equipment, electrical systems, and instrumentation.
- Safety procedures including gas detection, emergency shutdown, and confined space entry.
- Training programme and manuals to be submitted as part of mandatory documents.

15. OPERATION AND MAINTENANCE – GENERAL REQUIREMENTS

15.1 General O&M Obligations

The Concessionaire shall ensure safe and efficient running of the plant of the O&M period.

15.2 Civil O&M Requirements

- Carry out periodic inspection and maintenance of all civil structures, roads, drains, and buildings.
- Maintain all structures free from cracks, seepages, and settlement.
- Ensure all anti-corrosion coatings and linings are intact; repaint as required.
- Maintain landscaping and horticultural activities throughout the concession period.

15.3 Mechanical O&M Requirements

- Carry out preventive maintenance (PM) of all mechanical equipment per OEM-recommended schedules.
- Maintain all process vessels, piping, valves, and safety devices in sound condition.
- Replace activated carbon media, VPSA adsorbents, membrane modules, and other consumables at prescribed intervals.
- Maintain all seals, gaskets, packing glands, and flexible joints; replace at scheduled intervals.

15.4 Electrical O&M Requirements

- Carry out routine inspection and PM of transformers, switchboards, MCC, UPS, DG set, and motors per relevant IS standards.
- Maintain protective relays, trip circuits, and interlocks in calibrated and tested condition.
- Carry out earth resistance testing annually; ensure resistance values remain within specification.
- Maintain all hazardous area electrical equipment per PESO/ATEX requirements.

15.5 Instrumentation O&M Requirements

- Carry out calibration of all online instruments, gas analyzers, and flow meters at prescribed intervals (minimum annually); calibrate gas analyzers per ISO 17025 accredited laboratory.
- Maintain SCADA historian, ensure data backup, and verify system redundancy monthly.
- Test all gas detectors, flame detectors, and fire detection/suppression systems monthly.
- Maintain CCTV system; ensure minimum 60-day recording backup at all times.

15.6 O&M Reporting

- Maintain daily plant operating records.
- Submit weekly MIS (Management Information System) report to the Authority.
- Provide real-time data update to the Authority; monthly reconciliation.
- Any production shortfall deductions shall be settled quarterly per the Penalty Clause in the Special Conditions of Contract.

15.7 Security and Staffing

The Concessionaire shall deploy adequate security personnel at all times for the safety and security of the plant. Indicative staffing requirements including experienced supervisors and skilled personnel for the O&M contract shall be as described in the Special Conditions of Contract.

15.8 Handover on Completion of O&M Period

On completion of the contractual O&M period, the Concessionaire shall replenish and hand over all mandatory spares, fire-safety items, and any other items provided at the start of the O&M period in proper condition.

16. INDICATIVE/ SUGGESTEDVENDORS LIST

The following is the list of indicative/suggested vendors for electro-mechanical, instrumentation, and critical process equipment for this Contract. The naming of a manufacturer is intended to establish a standard of excellence and not to eliminate competition.

16.1 Gas Analysis and Flow Measurement

All instruments must be suitable for the specific hazardous area classification (Zone 0, 1, or 2) where biogas is present.

Category	Approved Vendors
Gas Analysers (CH_4, CO_2, O_2)	ABB Ltd (BU-Analytical), Chemtrols / Maihak, Emerson Process Management, Endress+Hauser, Yokogawa, Siemens AG, Ametek Inc.
H_2S and Total Sulphur Analysers	ABB India Ltd, Barton Instrument Systems Ltd
Gas Chromatographs	ABB, Emerson, Yokogawa, Siemens, Applied Automation Inc.
Flow Meters (General)	Emerson, Yokogawa, Endress+Hauser, ABB, Krohne, Hitachi High-Tech

16.2 Gas Compressors and Blowers

Category	Approved Vendors
Biogas Sliding Vane Blowers / Compressors	Swam, Mapro, Roflo Compressor
Air Compressors (Standard)	Ingersoll Rand, Kaeser, Kirloskar Pneumatics, Atlas Copco, Chicago Pneumatics, Elgi Compressor
Centrifugal Air Blowers	ABS Sulzer, Siemens, Turbomax, Neuros (Usha Neuros), Aerzen

16.3 Biogas Process and Safety Infrastructure

Category	Approved Vendors
Biogas Scrubber System and Dryer	CRA Energy, GGE Power
Biogas Flare System	Green Power, CRA Energy, GGE Power
Biogas Engines and Accessories	GE Jenbacher (Clarke Energy), Siemens (GGE Power), MWM (Green Power)
Slurry Pumps	A.R. Wilfley India, Akay Industries, Flowmore Ltd, Greaves Ltd, Kishore Pumps, KBS Pump

16.4 Automation and Electrical Systems

Category	Approved Vendors / Models
PLC and I/O Modules	Schneider Electric M580 (X80 IO), Siemens S7-414H (ET200 SP IO), Allen Bradley Control Logix L8 (POINT IO), Mitsubishi R16P M Series, Omron CS1D / CJ / Sysmac Series
SCADA Software	Aveva Plant SCADA, Simatic WinCC Explorer, Factory Talk, MC Works, CX-Supervisor
LV Switchgear (PCC/MCC)	Schneider Electric, ABB, Siemens, GE, L&T, Mitsubishi Electric
VFD / Soft Starters	Siemens, ABB, Schneider Electric, Mitsubishi Electric, Yaskawa, Danfoss

16.5 Criteria for Alternate Vendors

The Concessionaire may propose alternate vendors subject to approval by the Engineer. To qualify, alternate vendors must:

- Provide End User Performance Certificates for at least 5–10 successful installations of similar size operating satisfactorily for a minimum of 5 years.
- Demonstrate that the proposed make is technically equivalent or superior to the approved list.
- Submit ISO 9001:2015 certification and product brochures detailing local service and spare parts support.
- Ensure products are completely manufactured in the country of origin; assembled products are generally not accepted.